Past, Present and Future Computer Assisted Communication Training at NTID

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The National Technical Institute for the Deaf, Division of Communication Programs has developed three computer assisted instructional programs for auditory training and speechreading. These programs are described and some illustrative data regarding their effectiveness is shown. The three projects closely reflect the trends in computer assisted instruction over the past ten years and demonstrate the advances made in the technology and decreasing costs brought about by the implementation of microcomputers in education.

This paper describes three computer assisted instruction (CAI) projects for communication training which have been designed and used at the National Technical Institute for the Deaf (NTID) over the past ten years. We began using CAI by applying this new educational technology to existing curricula. Now, however, we are using the wider concept of computer based education (CBE). CBE includes not only the computer to present the stimuli to be learned but encompasses: (a) the management of educational resources and, (b) the research needed to study learning methods and curriculum as they interact with students' abilities.

IBM 1500 TELEPHONE SIGNAL TRAINING

Our first computer assisted lesson was developed for auditory training in 1972. The IBM 1130/1500 series computer of that time had the capability to randomly access audiotape stimuli which is an essential feature for this application. This lesson was a demonstration exercise for discrimination of telephone signals.

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The lesson began by asking students the function of the dial tone, the ring-back signal, the line-busy signal and the misdial warning. A multiple choice format was used to match the signal name with its function. The student then used earphones to listen at a comfortable loudness level to the four telephone signals via the output of the random-access audio tape player with an auxiliary amplifier. A pre-test of discrimination skills for the signals was completed by randomly selecting the four signals and requiring students to select which signal was heard from the four alternative choices printed on the computer screen. If the student could not correctly discriminate at least 3 of the 4 presentations of each of the signals, practice was required in which the student heard the signal 4 times with it identified on the screen. Additional practice repetitions were under student control. A post-test followed.

Typically this lesson was completed in 15 minutes. Programming for the lesson took 1233 lines of Coursewriter code and about 70 man-hours of programming time to complete and revise. Fifteen deaf students completed this program before reoccurring malfunctions with the random-access audiotape forced us to cancel the project.

Data regarding pre- to post-test performance was fragmentary due to the number of students who reached proficiency level on the pre-test. Of interest is the comparative difficulty in identification of the four telephone signals among this sample of 15 deaf students. Figure 1 shows the percentage of signals correctly identified by all subjects across the four trials of the pre-test.

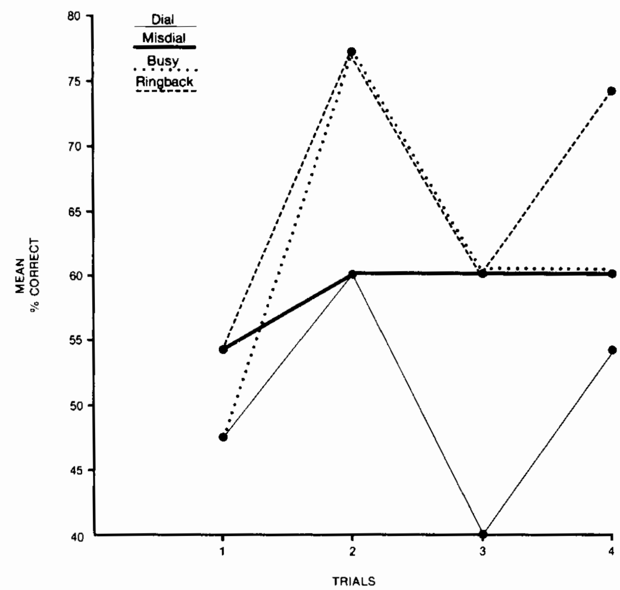

Figure 1. Trial by trial telephone signal identification performance for 15 deaf adults.

Note identification is poorest for the steady-state dial tone. The misdial warning is identified next best with its siren-like frequency-modulated sound. The ring-back and busy signals were most easily identified possibly due to their on-off signal characteristic.

The IBM system also allowed for measurement of the latency of student's responses. Latency of response is a generally recognized measure of the difficulty level of a learning task (Restle & Davis, 1962). It is helpful in CAI research because when mastery learning is required by the instructional program, there is little variability among subjects, i.e., all subjects have achieved, for example, 90% correct. This in turn yields poor correlational and reliability findings (Tatsouka & Tatsouka, 1978). Latency scores on the other hand typically show great variation across students. An individual subject's data for latency of response is shown in Figure 2. The response latency has a general decreasing trend over the 8 trials (4 pre-test and 4 post-test with an intervening period of subject controlled listening practice). For this subject, latency might have been used to control the amount of drill by examination of the history of response and a subsequent conclusion that further practice might be beneficial until the latency of response had stabilized at some lower level representing best possible performance.

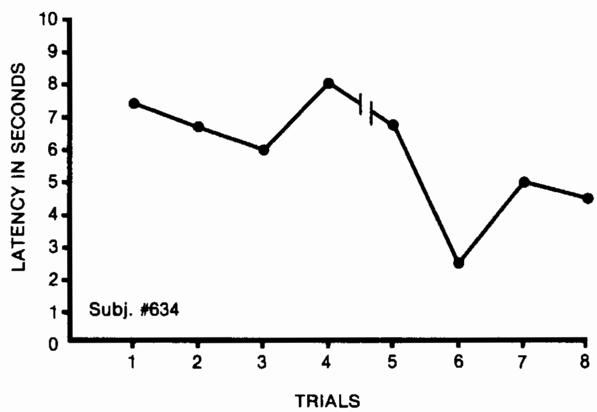

Figure 2. Average latency for four telephone signals over 8 trials.

Deaf students' written opinions about the computer assisted instruction exercises were generally positive, but they were critical of the details of our first exercise, citing the need to: (a) have paired comparisons rather than 4 repetitions of a given signal, (b) use their own hearing aids instead of the earphones, (c) improve the reliability of the system, and (d) expand this type of practice to speech communication.

For four years CAI auditory hardware training lay dormant, with NTID finding it difficult to maintain the IBM system after technical support was discontinued by IBM. These matters became intolerable when CAI lessons that had previously been successful, became inoperable.

The use of CAI in education in general declined during the 70's due to the heavy costs of hardware and continued personnel expenses for programming and maintenance. These expenses far outweighed the amount of curricula which actually *required* computer asssitance. Instructors were often misguided as to the purpose of CAI and programs were developed which were described as books with million-dollar page turners (Hebenstreit, 1981).

PLATO AUDITORY VOWEL TRAINING

One government sponsored, large CAI project which grew and prospered during this period was the PLATO System (programmed logic for automated teaching operation). The PLATO system is a series of regional and worldwide centers to which student terminals are connected via telephone. Twelve thousand hours of curriculum are available to students at all grade levels. The system also features sophisticated graphics and instructional management facilities. It is now marketed in several hardware configurations by Control Data Corporation.

NTID began surveying PLATO's curriculum several years ago, and since it also had the capability for high speed random-access of prerecorded audio stimuli, the NTID Communication Division designed a prototype auditory vowel discrimination training lesson.

Prior to beginning the project we conducted an electroacoustic evaluation of the audio output of the PLATO random-access (model KA 4096) system. We found that: (a) wow and flutter distortion was greater than 10%, (b) the frequency response of the system changed somewhat as the volume control was rotated, and (c) the frequency response also changed as one recorded on the first versus the last tracks of the magnetic platter. Consequently an accessory amplifier (J.L. Warren DS/1 with TDH 140 earphones) was used to amplify the output and provide a more stable frequency response across volume settings. Since the audio stimuli used for training were limited in number, all stimuli were recorded on the outer tracks of the disk for the best frequency response.

NTID students used the vowel training exercise as part of their out of class assignments for a program in basic auditory training. The prerequisites for this program are: (a) consistent and appropriate hearing aid use, (b) average hearing loss of 90 dB or greater, (c) auditory speech identification scores on the CID Everyday Sentences Test (Davis & Silverman, 1970, p. 492) of 25% or less, and (d) less than 75% correct in the auditory and visual mode combined on the CID Everyday Sentence Test. The student chose to listen to either a male or female voice. Then the first of 13 randomly selected vowel sounds were heard. S/he then chose the vowel that most closely matched what was perceived by touching the box on the screen that enclosed that vowel printed in an /h/vowel/stop/consonant context (see Figure 3). That selection was then played back via the random-access disk. The student, for example, would hear /i/ in isolation and then select the target vowel as given in the printed word "heat" after listening to several alternative vowels. The student was able to listen to the vowel sounds as many times as required in order to match the sound and the word. The student pushed the "match" button followed by the selected response item to declare a match and receive feedback. The selected vowel response box was covered with an X if the student was incorrect and the student could try again. When the correct box was touched the student was given feedback like "you got it" etc. The 13 target vowel sounds were randomly presented four times. The student then had the option to practice this task again with the other voice.

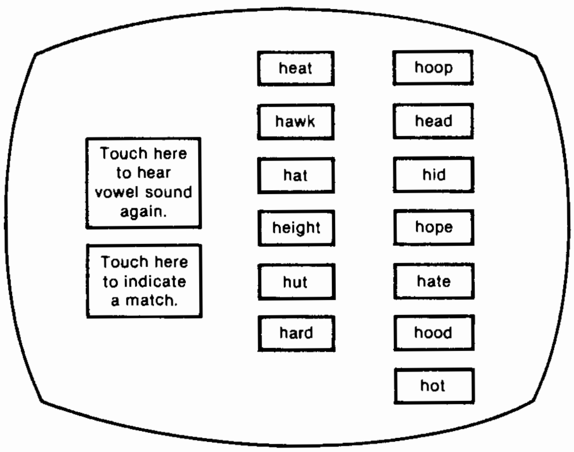

Figure 3. PLATO vowel discrimination training stimulus control and response display.

Information gathered relative to this training included: (a) students' opinions regarding the value of the training, and (b) the latency of response to correct identification of the vowel. A summary of evaluation results for thirteen students are shown in Figure 4. These results indicate generally favorable responses to the two- to four-hour lesson and there were no particular problems with the lesson design in terms of clarity and feedback given to the students.

Improvement of the students' skill for identification of the vowels was analyzed for six cases whose data was available at the time of this writing using the latency of correct responses across the first versus the last (fourth)

STUDENT AFFECT QUESTIONNAIRE

This Plato lesson was:

very hard	hard	just right	easy	very easy
	5	4	3	1

I feel this lesson helped me to understand the things I studied in class

much better	a little bit better	about the same	a little less	much less
1	8	3	1	

When I got an answer wrong, the lesson helped me

all the time	most of the time	one-half of the time	sometimes	never
	3	6	2	1

I liked this PLATO lesson

yes	no
10	3

Did you have problems with the machine?

yes	no
2	11

Figure 4. Excerpts from student affect questionnaire administered post-training.

replication of each vowel token. It was hypothesized that as the vowels become easier to identify, there would be a trend for the latency for correct responses to decrease. Summary data is presented in Figure 5 which depicts the latency to correct response in seconds for four representative vowels at the corners and center of the vowel triangle. A trend toward decreased latency is present.

In general, our experiences with the PLATO were similar to those with the IBM system, except that the random-access audio unit worked better mechanically. However, it did not have the auditory fidelity and freedom from distortion that one would want in an auditory training system (a newly designed random-access audio unit is now available). We found the touch screen response mode to be very helpful because of its simplicity for this kind of response task. Programming requires knowledge of PLATO's TUTOR language which was designed for teachers to use without prior programming skills. However, because of the flexibility of this language, it has become rather complex. Several months were required to complete the programming for this lesson. At this time NTID is discontinuing use of the PLATO system because of the rental cost. Also, the college level PLATO curriculum is not directly useable due to the below-average linguistic competence levels of our students.

DAVID INSTRUCTION

The previous two projects were attempts to apply educational technology to specific content components of auditory training. However, the next CAI

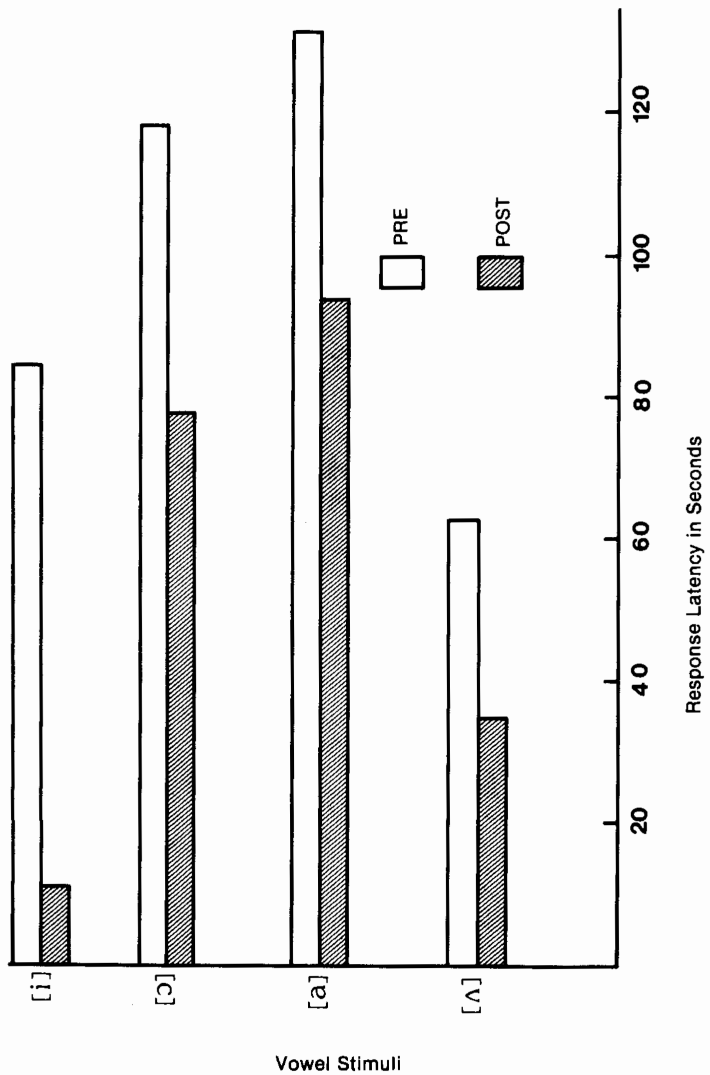

Figure 5. Mean latency to correct response for vowel discrimination training.

project was much more comprehensive as the media was designed to meet our needs for improved self-instruction drill and practice procedures for speech-reading training.

To accomplish this we specified computer control for the videotape media. We were already successfully using a large collection of videotaped exercises, however, a number of improvements were needed for the management of the self-instruction and there were limitations in the stimulus handling capabilities of the videotape players (Sims, 1980). For example, students could not easily repeat stimuli without a wait of 20 seconds, and since students' responses were self-corrected by paper and pencil, there was error, wasted instructional time, and lost information.

The Dynamic Audio Video Instructional Device (DAVID) was developed at NTID to improve the visual stimulus handling during instruction and to add computer based curriculum/student management. With this system, stimuli of any duration, and in any order, can be presented to the learner. There is program control over the two audio channels. Slow motion and student recording can also be used in a lesson. Videotape rather than video-disk was used because of the high mastering costs of disk and our anticipated low production volume. To date, we have not experienced any student frustration as a result of the comparatively longer access times with the videotape. We have, however, tried to anticipate student accesses to the tape and position the tape in advance if possible. The DAVID hardware consists of a Solutions Corp. random-access video equipment (RAVE) controller which is a Z-80 microcomputer dedicated to controlling the modified videotape recorder (VHS format, JVC Model BJ6400U or Beta Max format, Sony Model SL0323). The controller interfaces with an Apple II Plus computer with three 5¼″ disk drives. The RAVE unit is capable of accessing a specified point on a tape to within 1/15 of a second without *any* drift off-target. It accomplishes this by laying down and reading a digital time code in the video-sync track of the tape recording. A digital tape identification code also is continually read in order to be certain that the correct tape is being used with the lesson. Several programs designed for communication training with the DAVID system are described below.

DAVID Speechreading Instruction

The first DAVID program is a speechreading exercise in which students view a series of videotaped single sentences and type into the computer what was said, verbatim. The student may view a sentence item again at any time by using a "repeat" function key. The student may also use a "help" key when experiencing difficulty. "Help" is given in three ways: first, a hint is given concerning the subject matter of the sentence. The second through the sixth "help" requests result in a fill-in of the first missing or incorrect letter in the student's typed-in response attempt and the seventh and all subsequent helps are a fill-in of the first missing or incorrect word. After each two successive help requests the student is forced to view the sentence again. Frustration resulting from difficult speakers or complex sentences is minimized while insuring that the student receives a significant amount of experience with a difficult item. A score for each sentence is derived by a formula that uses the number of helps, repeats, and the latency of the correct response. If the student's score falls below an arbitrary criterion level, s/he must review the sentence at the end of the lesson block of 25 sentences. In order to facilitate more rapid student responses, gist word correction is also a feature of this program. Thus, if a student types in the subject, verb and object, (and other key words necessary to the meaning) the computer will score the sentence correct and show (blinking on and off) the missing functor and other words in the sentence on the computer screen. For research and instructional management purposes, all student keystrokes, response latencies, and stimulus presentation conditions are stored.

To determine the value of computer assisted interactive instructional television for a speechreading drill and practice, we are using several measures: (a) the traditional pre-post-test of sentence-length speechreading ability, (b) student self-reported skill improvement and attitude toward the instruction, and (c) the time to correct response. We are mid-way in the data collection process at this time. However, data collected to date illustrates the need to broadly base the evaluation of this type of project.

With deaf learners it is important to carefully determine the validity and reliability of pre-post-test instrumentation (Sims, 1983; Thornton & Raffin, 1980). The parallel pre- and post-tests must be similar in response format. And, the tests must be equal to the practice task in level of difficulty. Two measures of speechreading ability have been found useful at NTID (Sims & Jacobs, 1976). The first is the Jacobs test which consists of 20 everyday language sentences. One hundred key words embedded in the sentences are used to score the test. The second is the Survival test which contains key words taken from the practiced materials. These key words are embedded in 20 novel sentence contexts and students were scored on the proportion of 100 key words correctly identified.

Pre- and post-test scores on these tests for the 15 subjects at hand for this informal analysis were extremely high (see Table 1). Consequently, little variance was available in which to demonstrate gain. Yet the students reported via questionnaire, that the drill and practice had been beneficial to their speechreading skills. This result led us to examine the utility of time to correct response as a measure of speechreading skill. In this way we might be somewhat more independent of the pitfalls of typical pre/post-test measurement.

Our approach to time-based skill assessment began with establishing the

Table 1

Survival and Jacobs Speechreading Pre- and Post-Test Scores for 15 Students Who Received Computer Assisted Speechreading Training on the DAVID System

	Pre-Tests		Post-Tests	
	Survival	Jacobs	Survival	Jacobs
M	75%	89%	80%	92%
SD	13%	10%	14%	7%

time to correct response on all of the 175 everyday "Survival" drill sentences. This data was used to establish the comparitive item difficulty of each sentence. To accomplish this, 38 students practiced speechreading sentences in blocks of 25 using the DAVID system. The first block was for familiarization with the student/computer interactions described above. Students completed a block of sentences in from 30 to 60 minutes. The mean latency for a correct response to a single sentence was 1 minute, 19 seconds (s.d. = 1 min. 19 sec.). For the latency-performance analysis, 12 probe sentences were selected (two from each of the six blocks of sentences). These probe sentences had means and standard deviations as close as possible (within plus or minus 20 seconds) to the one minute, 19 seconds over all mean and standard deviations of all 175 sentences. In this manner, if one assumes that latency to correct response for the entire group of subjects is related to item difficulty, we could select average difficulty level sentences which could be used as probes of individual (or sub-groups of student) speechreading skills over the course of the practice sessions. Since the probe sentences were spread throughout the lesson, our intention was to monitor whether students' skills were improving with time as a function of any apparent trends towards decreasing time to correct response. To counterbalance for learning and/or fatigue effects, half the subjects had practiced the Survival sentences in ascending order and half in descending order.

Figure 6 is a plot of the latency for correct responses for the first through the last occurance of the probe sentences. There is a trend toward decreased latency as these students moved through the 175 sentences. Since the general orientation effects had been removed by the initial practice block, we suggest that latency measures were related to improvement in speechreading skill for these subjects.

We are continuing to examine a broad range of NTID students' performance and affective reaction to the DAVID speechreading lesson described above while also programming new lessons which will expand the interactive capabilities of this educational media.

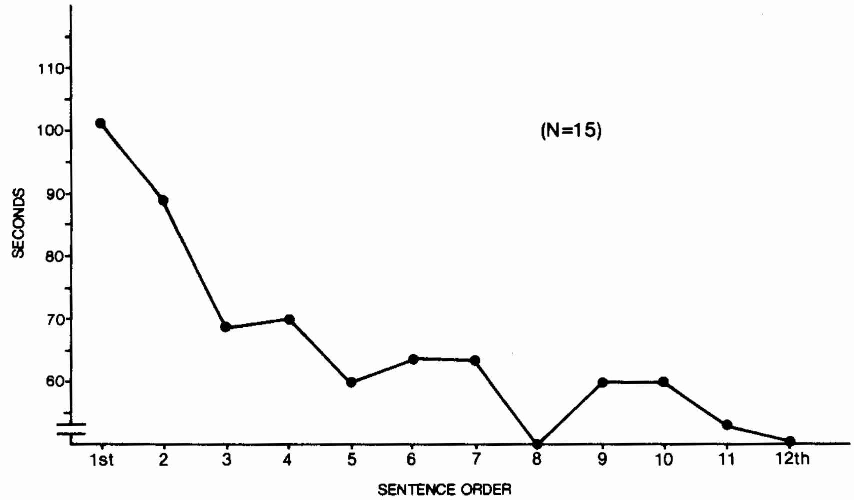

Figure 6. Mean time to correct response for 12 probe sentences.

DAVID Sign Language Instruction

A lesson in sign language nearing completion encompasses communication training for word, sentence and paragraph reception into one lesson. Sign language reception is the skill trained, but oral/aural receptive modalities could be used as well. The student uses a videotape "dictionary" to look up and study unfamiliar signs articulated in isolation. Then a student may elect to see the sign used in a sentence with the "help" key used to supply whole words one at a time to aid the student's response attempt via the computer keyboard. To complete the lesson, however, the student must view a paragraph length monolog and correctly answer comprehension questions concerning its content. If any question is incorrectly answered, the program coaches the student by suggesting a review of relevant words and sentences from the practice section. Thus, in this lesson, the required terminal behavior is paragraph comprehension which approaches the desired functional communication skill; yet the student can practice on the item or sentence level according to self-determined need and/or the coaching of the computer.

DAVID Job Interview Simulation

The final example of DAVID System programming is the simulation of real dialogue using the situation of a job interview. The student's task is not only to speechread but to use strategies which allow successful communication to take place regardless of oral/aural receptive skills. First, the student fills out an application for a job using the computer keyboard, then, depending on the entries, the pre-recorded video sequences are presented of the job interviewer asking questions. The student must then type in answers to the interviewer's questions. Again, depending on those answers other video segments are selected by the program. In this manner a student can try several options for response and experience the consequences without real penalty. In this task, the interactive potential of the DAVID concept is maximized and realistic simulation is the result. Further work in this area is under way by Brenda Whitehead and William Clymer at NTID.

CONCLUSION

We have presented three computer assisted communication training projects which have shown growth in complexity and expanded capacities for both management of instruction and stimulus handling capabilities. At the same time, hardware costs have been reduced (see Appendix A).

In general, we believe that the DAVID System is a highly flexible educational media for drill, practice, and simulation in communication training. The software used to create these programs is fully documented and is in the public domain to those involved with these matters. We feel that implementation of the DAVID type systems in speech and hearing clinics will bring exciting new dimensions to routine communication training and allow exploration of entirely new methods of learning that were previously impossible.

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APPENDIX A

DAVID EQUIPMENT: COSTS AND SUPPLIERS

Item	Price	Supplier
Apple II computer	1300	local
3 disk drives, 2 controller cards	1600	local
JVC BJ6400U videotape recorder[1] VHS Format	1400	local
RAVE videotape controller[2]	4000	Solutions Co. 3740 Colony Drive Suite 130 San Antonio, Texas 78230

[1]The Sony Beta Max videotape recorder, Model SLO 323, may be used in place of the JVC machine.

[2]Video controllers and authoring languages are also available from:

BCD Associates, 1216 North Blackwelder Avenue, Oklahoma City, OK, 73106 (Panasonic 8200)

CAVRI, 26 Trumbull Street, New Haven, CT 06511 (Sony Beta Max)

Ashton, 209 Tracy Creek Road, Vestal, NY 13850 (Sony Beta Max)

Von Tech, 1320 Buffalo Road, Suite 111, Rochester, NY 14624 (Sony Beta Max)